Cosmic Chemistry: An Elemental Question

Connecting Models and Critical Questions

TEACHER ASSESSMENT GUIDE

Background Information

Assessment data should provide students and teachers with feedback on how well the expectations of teachers, parents, the school, etc., have been met. Assessment practice operationally defines what is important. The tasks in which students engage signal what students are to learn, how teachers are to teach, and how resources for that instruction should be allocated.

The National Science Education Standards sets standards in assessment as well as content to be covered. Assessment Standard B explains that any achievement data collected should focus on what is "most important for students to learn." The science content standards include outcomes such as understanding concepts and theories; abilities to reason scientifically, to inquire, and to use science to make decisions and solve problems; and the ability to effectively communicate findings. In this module, these outcomes have been addressed in various learning environments focused on understanding the development and interpretation of the periodic table of the elements. Throughout *Cosmic Chemistry: An Elemental Question*, students have inquired, developed mathematical models, and engaged in exercises aimed at connecting science theories and concepts with the models being developed. Students not only engaged in logical reasoning, decision-making, and problem-solving, but these processes were studied for their own merit, through record-keeping, logging of decisions, and extensive classroom discussion.

Since measurement practice in the past has been most concerned with measuring student knowledge about subject matter, there is a scarcity of good instruments designed to measure students' active knowledge, the understanding and ability to inquire, reason, and utilize knowledge. It is essential that these types of student learning be assessed if this is a desired learning outcome. The processes of student learning and assessment are so inextricably linked that if the appropriate outcome is not assessed, students and teachers will redefine their learning expectations to the outcomes that *are* being assessed.

In this assessment exercise, students are challenged to draw upon what is known (or given) to develop a mathematical model upon which they can base explanations about the diversity of the chemical reactivities of various elements. The focus is on questioning, data manipulation, modeling, and logical reasoning as emphasized throughout the entire module. It is not necessary that the students' work result in the same models explained in the guide for teacher use and understanding. What *is* necessary is that students address the problem with their approach, that they clearly demonstrate a logical reasoning and modeling process, and that they question the results and inconsistencies in their model.

Problem

Create a model to explain differences in chemical reactivity among certain elements, using the Characteristics of Elements Data Set.

Standards Addressed (Grades 9-12)

Science as Inquiry

- IDENTIFY QUESTIONS AND CONCEPTS THAT GUIDE SCIENTIFIC INVESTIGATIONS
- USE TECHNOLOGY AND MATHEMETICS TO IMPROVE INVESTIGATIONS AND COMMUNICATIONS
- FORMULATE AND REVISE SCIENTIFIC EXPLANATIONS AND MODELS USING LOGIC AND EVIDENCE
- COMMUNICATE AND DEFEND A SCIENTIFIC ARGUMENT
- UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY

Physical Science

- STRUCTURE AND PROPERTIES OF MATTER

Materials

For each student (assessment will be done on an individual basis):

- Student Activity, "Connecting Models and Critical Questions"
- Calculator or computer
- Graph paper (see Teaching Tools)
- Pencils (colored pencils are also helpful)
- All activities and notes completed throughout module

Table 1: Characteristics of Elements Data Set

Element	Atomic Number	Period	Group	First Ionization Potential (volts)	Electro-negativity	Boiling Point (°K)	Atomic Radius (Å)	Specific Heat Capacity J/g/°K (at 300°K)
H	1	1	IA	13.598	2.1	20.28	2.08	14.304
He	2	1	0	24.587	0	1.216	( )	5.193
Li	3	2	IA	5.392	0.98	1615	1.55	3.582
Be	4	2	IIA	9.322	1.57	3243	1.12	1.825
C	6	2	IVA	11.26	2.55	5100	0.91	0.709
F	9	2	VIIA	17.422	3.98	85	0.57	0.824
Ne	10	2	0	21.564	0	27.1	0.51	1.03
Na	11	3	IA	5.139	0.93	1156	1.9	1.23
Mg	12	3	IIA	7.646	1.31	1380	1.6	1.02
Si	14	3	IVA	8.151	1.9	2630	1.32	0.7
Cl	17	3	VIIA	12.967	3.16	239.18	0.97	0.48
Ar	18	3	0	15.759	0	87.45	0.88	0.52

Procedure

1. Discuss the purpose and goal of this assessment activity with students. Pass out Student Activity, "Connecting Models and Critical Questions." Call attention to the Characteristics of Elements Data Set supplied in Table 1.

2. Discuss the terms in the chart that describes elemental characteristics so that all students understand their meanings. Ask students to examine the table for any columns or rows of data that look interesting. Using the technical terms in class discussion will help students to begin to draw connections among certain pieces of important data.

3. Tell the students that some of the data is more relevant than other data in solving the problem of explaining how an element's chemical properties depend on its location in the periodic table. It is their job, however, to determine which data is most useful, how it can be used to give the most reasonable model and explanation that illustrates diversity in element reactivity orbits. For your information, the columns with data on group (within a period), first ionization potential and electronegativity are most useful. Students will likely see that these (or at least two of the three) are connected to the problem they are trying to solve. Encourage students to pose questions that ask about relationships between characteristics. These might include questions such as:

   a. How do first ionization potentials of an element compare across a period?
   b. How do electronegativities of elements compare across a period?
   c. How do electronegativities of elements compare to their first ionization potentials?
   d. How do the atomic radii of elements compare with their first ionization potentials?

   Try to not supply these questions directly to students, however, as determination of what information is useful in an investigation is one of the abilities you are trying to assess.

4. From this point, students should be made aware that they are to develop one or more mathematical models that illustrate the data in useful fashion. Remind students that they should not expect to create appropriate models the first time around, and that you are prepared to allow them to continue work on their modeling and explanations throughout the period. Consider allowing an additional period(s) for certain students or classes so that their efforts are not compromised.

5. With students working in groups for 15-20 minutes, allow the group problem-solving process to begin. Students should take notes from this group discussion about various approaches to solve the problem. After 20 minutes, separate the students and have them complete the assessment individually.

   As students work, they should record their questioning and decision-making processes in much the same way as in the Successful Problem-solving Process Log. They should also respond fully to each of the questions. Prompt them to read the questions before they begin to model the data. The questions are designed to elicit responses to help you determine their level of understanding of a myriad of processes and concepts, such as interpolation, identifying and explaining anomalous data, using prior learning, identifying and minimizing sources of error, etc.

Alternate Assessment Tip

If time permits, lab groups could plan and make a class presentation. Then item 4 in the Student Activity, "Connecting Models and Critical Questions," could be used as a pre-planning activity.

6. Some students will create a graph similar to one of the model solutions given in the Representative Graphs. However, others may utilize ratios. If so, look for a ratio of the electronegativity to ionization potential versus electronegativity to atomic radius, or some other similar approach. Should irrelevant information, such as the boiling point, be used, the answers should not be dismissed as incorrect. Remember, the identification of the appropriate data is important, but so is the modeling, explanation of anomalous data, interpolation, spotting sources of error, planning for improved processes of problem-solving, and communication of data and problem-solving processes.

7. Note that this is an individual assessment, although much of the work during the module has been done in lab groups. It is important, when doing group work, that students are held individually accountable as well.

Representative Graphs

Figure 1

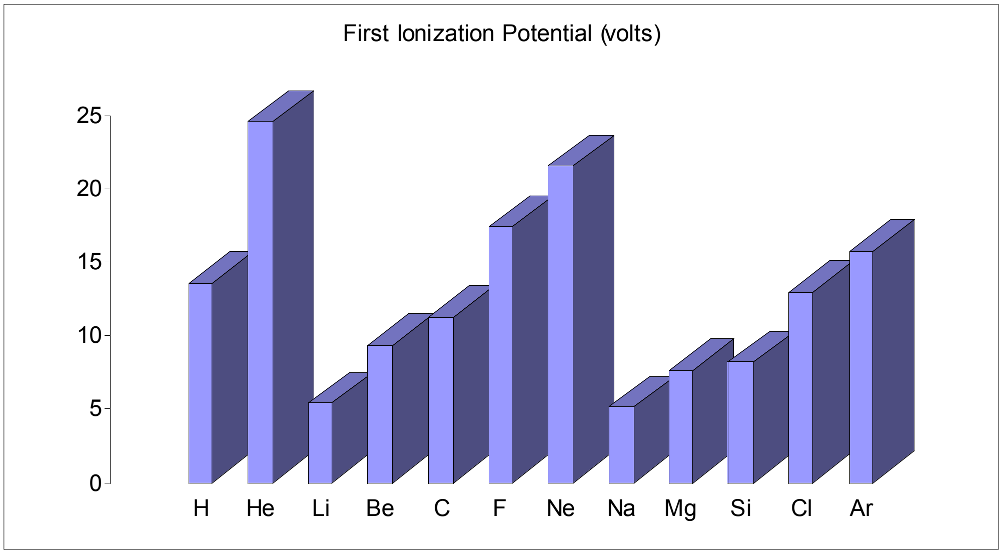

Figure 2

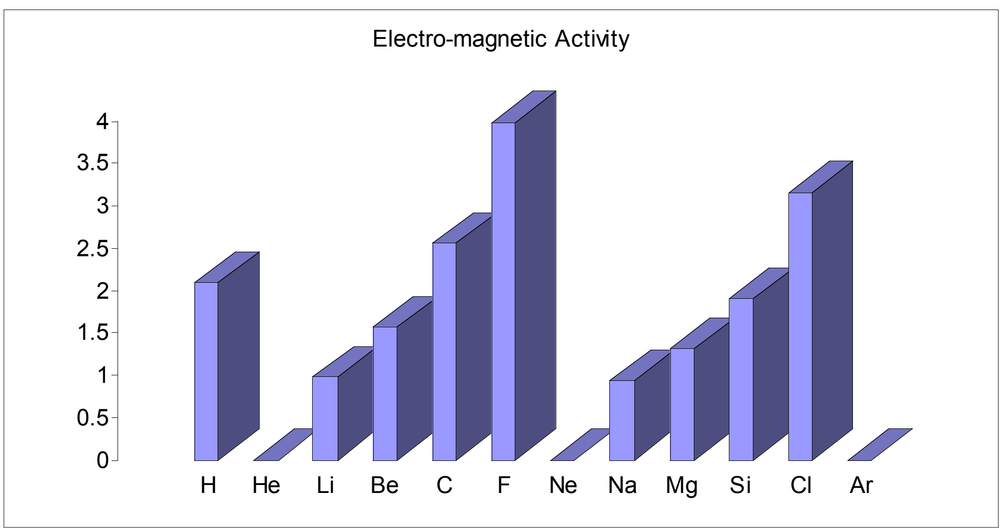

Figure 3

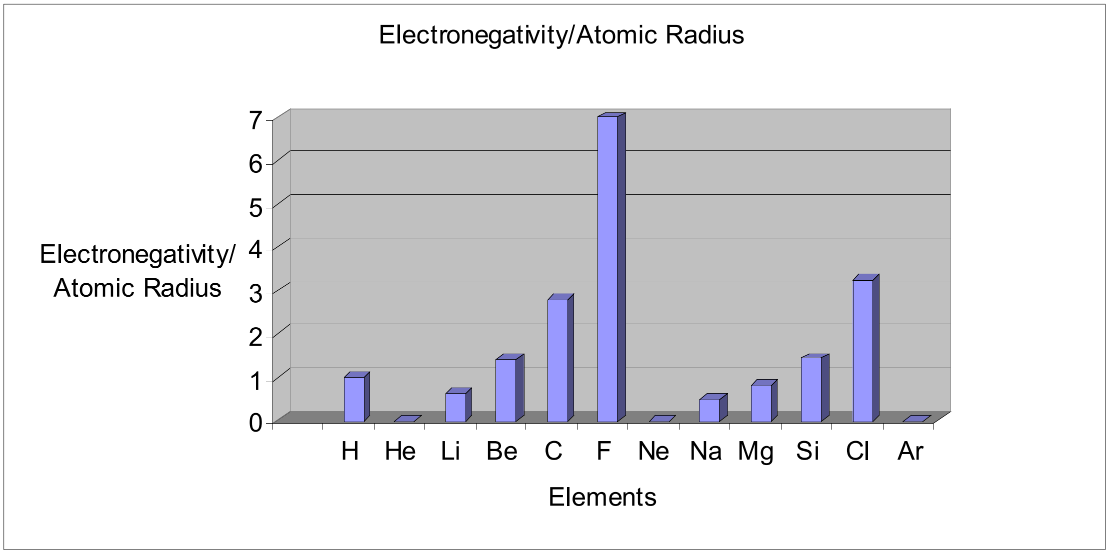

Figure 4